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REMOTE STORAGE

Bacteriological Analyses of Ottawa River Water

By

F. C. HARRISON AND J. VANDERLECK

Bacteriological Laboratories, Macdonald College, P.Q., Canada.

OTTAWA

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II.—*Bacteriological Analyses of Ottawa River Water.*

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(Read May 27th, 1909.)

The water of the Ottawa River has been characterised as an "upland peaty" water, and the results of a number of analyses made by Shutt and others show it to be of fairly constant chemical composition. It contains a rather high percentage of organic and volatile matter, as indicated by the marked albuminoid ammonia and loss on ignition, and the total solids are low.

The following table gives the average of six analyses made by Shutt and Spencer[1]—arranged in two groups, one under summer and the other under winter conditions.

DATE.	LOCALITY.	Free Ammonia.	Albuminoid Ammonia.	Nitrogen in Nitrates and Nitrites.	Chlorine.	Total Solids at 105°C.	Solids after Ignition.	Loss on Ignition.
		ppm.	ppm.	ppm.	ppm.	ppm.	ppm.	ppm.
May 8, 1899	Tap in Lab., Central Exp. Farm, Ottawa.....	None	.177	.107	.3	48.8	22.8	26.0
Aug. 22, 1905	Intake No. 4 Crib, Ottawa	.010	.220	.100	.6	62.4	36.4	26.0
Mar. 12, 1907	Above Chaudiere Falls, Ottawa.....	....	....	....	....	54.6	30.6	24.0
Dec. 22, 1887	Mouth of clear water inlet, in front of screen, Ottawa.....	.020	.120	.148	.5	53.0	....	....
Oct. 18, 1898	Tap in Lab., Central Exp. Farm, Ottawa.....	.008	.145	.059	.6	55.6	34.0	21.6
Dec. 7, 1898	Tap in Lab., Central Exp. Farm, Ottawa.....	.015	.233	.099	.2	42.4	28.0	14.4

According to R. A. Daly, the Geologist of the International Boundary Commission, the river above the city of Ottawa drains a typical pre-cambrian terrane, and the results of Shutt's and Spencer's

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analyses show "that the River Ottawa annually delivers to the St. Lawrence and the sea, per volume, only 20 per cent of the amount of calcium now annually delivered to the sea by the average river of the globe."

The accompanying sketch map kindly furnished by Mr. C. Coutlée, C.E., gives the course of the river between the cities of Ottawa and Montreal. From Ottawa to Grenville village, opposite Hawkesbury, is the 60 mile stretch of water navigated from Ottawa. From Grenville to Greece Point is 12 miles of rapid water with a fall of 50 feet. From Greece Point to Carillon there is a level, held up by the Carillon dam, twenty feet high, over which the river pours into the Lake of Two Mountains. At Ste. Anne's at the western end of the island of Montreal, there is a small fall of 4 or 5 feet. We are indebted to Mr. C. Coutlée, of the Georgian Bay Ship Canal Commission for the sketch of the daily discharge of the Ottawa River at Besserer's Grove for the years 1898-1906, inclusive, which gives by months the daily discharge of water, the straight line indicating the average for the year. To obtain the flow of water passing out of the Lake of Two Mountains, by months, it is necessary to add to the figures of the diagram as follows:

During May, 30,000 cubic feet per second.

During June, 20,000 cubic feet per second.

And rest of the year 10,000 cubic feet per second.

Twenty-five per cent of this amount passes Ste. Anne's; the remainder flows by Vaudreuil, Back River and St. Eustache.

The population living in the cities and villages on the river bank between Ottawa and Ste. Anne's is about 150,000, and only the following places have sewers which discharge into the river:—

Ottawa — population	.....	80,000
Hull "	.....	15,000
Hawkesbury "	.....	4,750

The remaining villages—Thurso (600), Papineauville (1200), Montebello (800), Calumet (400), Grenville (500), Carillon (300), and Ste. Anne's (1,200) on the north bank, and Rockland (3,000), L'Orignal (4,500), Point Fortune (400), Como (300) and Vaudreuil (600) on the south bank, have no sewers. The other villages shown on the map are situated back from the river's edge for half a mile or further.

The earlier analyses of the river water taken at Ste. Anne's, showed that *B. coli* was constantly present in small quantities of water, and hence it was important to find out if this contamination was due to infection from the sewage of Ottawa, Hull and Hawkesbury, or owing to surface drainage and pollution.

Shutt and Spencer from their analyses of the water taken at Ottawa, already quoted, class it as a good potable water.

Through the kindness of Dr. John A. Amyot, Bacteriologist of the Ontario Provincial Board of Health, we are enabled to publish the bacteriological findings of the water taken above the intake or from the taps in the city of Ottawa. We have arranged these in two groups, under winter and summer conditions, winter conditions being when the river was frozen over.

WINTER CONDITIONS (River frozen over).

DATE.	Number of samples analysed.	Number of samples infected with *B. coli* in 1 c. c. quantities.
January, 1906	1	None
December, 1906	2	None
January 12th, 1907	2	1
January 17th, 1907	2	None
February 8th, 1907	4	1
February 23rd, 1907	4	None
December 19th, 1908	2	None
December 24th, 1908	2	None
Total	19	2

SUMMER CONDITIONS (River free of ice).

DATE.	Number of samples analysed.	Number of samples infected with *B. Coli* in 1 c. c. quantities.
October, 1906	3	1
November 9th, 1906	1	None
November 13th, 1906	2	1
November 21st, 1906	1	None
April 5th, 1907	4	2
April 17th, 1907	4	0
August, 1908	2	0
November, 1908	1	0
Total	18	4

Thus about 16 per cent of all samples analysed were infected with *B. coli*, the infection when the river was frozen over being about 10 per cent, and 22 per cent when the river was free of ice. Dr. Amyot also reports two analyses of river water from Hawkesbury, in both of which *B. coli* was present in 1 cc. quantities.

These figures serve to show that at least the water starts above the city of Ottawa without much infection.

The river water intake pipe which provides the water supply of Macdonald College, at Ste Anne's, runs 150 feet into the river and obtains water at a depth of 12 to 14 feet. The samples for analysis were taken at the pump, in sterilised bottles and immediately brought to the laboratory and the analyses started.

The river water is pumped directly through a Jewel Filter manufactured by the "New York Continental Jewel Filtration Company." Ammonia alum is used as a coagulant, but there is no settling tank, the water being pumped directly into the distributing pipes.

The samples of filtered water were obtained from the power house, being taken from a faucet on the service pipe leading from the filter.

The analysis was commenced immediately, and all possible precautions were taken to ensure proper sampling and correct results.

The media employed were beef peptone gelatine and beef peptone agar, prepared according to the directions of the Laboratory Committee of the American Public Health Association. The colon tests were made in our æsculin bile-salt-agar medium, and subcultures of black colonies were frequently made on the set of media suggested by Savage and Houston [2] for the necessary identification of *B. coli*.

The two most striking features of the analyses were the large fluctuation in the total numbers of bacteria and the almost constant presence of *B. coli* in large numbers.

The direction and force of the wind and rain undoubtedly tend to produce higher bacterial counts. The river is wide, and after a strong breeze (particularly if it is in a direction opposite to the river flow) the water becomes very turbid and analyses made of such water invariably give higher counts. Rain also stirs up the water, but its greater effect on the bacterial content of the stream is due to the surface washings falling into the river. November, September, June and April gave the highest total counts, in the order named.

The chief interest in these analyses from the hygienic standpoint is the number of *B. coli*. The varying opinions which are held as to numerical standards of *B coli* are well known, but assuming that Savage's standard is about correct "that the finding of *excretal B. coli* in 10 cc. or less points to undesirable pollution, and that if *B. coli* is present in smaller amounts—*e.g.*, 1 cc. or less—the water can be safely condemned

as undesirable for drinking purposes," then the water of the Ottawa River at Ste. Anne's, at all seasons of the year, must be considered unfit for potable purposes. On three occasions only was *B. coli* absent from 5 c.c., and in these instances, although not shown on the table of results, we found the organism in 20 c.c. samples.

Excretal B. coli which we isolated continually from Ottawa River water at Ste. Anne's can only to a certain extent originate from the washings of land in cultivation or from accidental infection.

In winter time, the river between Ottawa and Ste. Anne's is covered with ice from 1 to 2 feet thick, for more than three months, and the only possible source of infection is the sewage of those towns on its banks which have a sewerage system, namely Ottawa (80,000), Hull (15,000) and Hawkesbury (5,000), with a total population of 100,000. As already mentioned the river above Ottawa is nearly free from *B. coli*, but the three towns mentioned discharge daily into the river 100 gallons of sewage *per capita*, which amounts to ten million gallons daily.

This large quantity of sewage is diluted according to the amount of water in the river at different times of the year, and in order to differentiate this sewage infection from contamination from all other sources, we must make a comparison of the amount of water discharged during the different months of the year.

In 1908 September and October were the months of very low water, and therefore their discharge is taken as a standard of comparison. In April four times as much water is discharged as in one of these "standard" months, whilst March has a discharge of twice of one of the lowest months. In this way all the months are tabulated.

September	1
October	1
August	1½
November	1½
December	1½
January	1½
February.	1½
March	2
July	2½
April '09	3
April '08	4
June	5
May	6½

This table is computed from 8 years' observations of the daily discharge of the river at Besserer's Grove. See sketch "Daily Discharge of the Ottawa River at Besserer's Grove."

The value of the above factors is that they give us the dilution of the sewage infection for the various months. For example, in April with factor 4 the sewage is diluted 4 times as much as in September or October.

The average number of *B. coli* per c.c. for the three winter months is, respectively, 22½, 16 and 5—an average of 14 *B. coli* per c.c. for the

three months. This number (14) must be subtracted from our monthly colon figures after correction with the dilution factor. For example, for the month of April the number 14 must be divided by 4, so that only $3\frac{1}{2}$ is subtracted from the monthly estimation of *B. coli* ($15\frac{1}{2}$)—$3\frac{1}{2} = 12$, which indicates the colon contamination per c.c. from other sources.

The monthly average number of bacteria growing on beef peptone agar at 37°C. is included in the following table.

TABLE SHOWING COLON CONTAMINATION FROM OTTAWA SEWERAGE AND OTHER SOURCES.

Month	Bacteria per c.c. on agar.	Total B. coli per c.c.	B. coli of sewage origin per c.c.	B. coli from other sources per c.c.
April	1,600	$15\frac{1}{2}$	$\frac{14}{4} = 3\frac{1}{2}$	12
May	200	12	$\frac{14}{6\frac{1}{2}} = 2$	10
June	1,700	9	$\frac{14}{5} = 3$	6
July	300	$4\frac{1}{2}$	$\frac{14}{2\frac{1}{2}} = 6$	0
August	400	$37\frac{1}{2}$	$\frac{14}{1\frac{1}{2}} = 9$	$28\frac{1}{2}$
September	4,175	88	$\frac{14}{1} = 14$	74
October	1,400	24	$\frac{14}{1} = 14$	10
November	9,600	*50	$\frac{14}{1\frac{1}{2}} = 9$	41
December	150	$6\frac{1}{2}$	$\frac{14}{1\frac{1}{2}} = 9$	0
January	200	$22\frac{1}{2}$	$\frac{14}{1\frac{1}{2}} = 9$	$13\frac{1}{2}$
February	75	16	$\frac{14}{1\frac{1}{2}} = 9$	7
March	30	5	$\frac{14}{2} = 7$	0
April	200	13	$\frac{14}{3} = 4\frac{1}{2}$	$8\frac{1}{2}$

* One exceptional analysis of 2,600 *B. coli* per c.c. is omitted.

A glance at the above table shows that infection with *B. coli* was greatest in September, followed by November, August and October, and it is significant that this period of high colon content exactly corresponds with the seasonal incidence of typhoid fever, a disease which is very prevalent in the villages on the banks of the Ottawa river.

It is unfortunate that we were unable to procure proper samples from various points between Ottawa and Ste. Anne's, and hence no direct comparison can be made between our results and those given by Jordan[3] for the Desplaines and Illinois rivers. It seems, however, from our results that considerable numbers of *B. coli* are carried down the river. The distance between Ottawa and Ste. Anne's is nearly 100 miles. A few miles below Ottawa the river bed contains very large amounts of sawdust, the accumulation of many years, as the large lumber mills at Ottawa used to dump all their refuse into the stream, a practice which has lately been prohibited. This material contains much organic matter, and undergoes slow decomposition. Large amounts of gas are frequently seen bubbling to the surface at Rockland. Undoubtedly some more solid parts of the sewage settle at this point. Owing to the rapids which commence at Grenville and continue twelve miles to Greece Point, the river flows very fast, but on entering the Lake of the Two Mountains, the water flows slowly, and this lake must, to a certain extent act as a settling basin. Mr. C. W. Coutlée, Assistant Engineer of the Georgian Bay Ship Canal Commission, estimates the flow of the river at two miles per hour during the spring months and half this rate during the rest of the year. This rate is somewhat faster than that of the Desplaines and Illinois rivers, and the amount of sedimentation is therefore probably less. During the winter of 1908-9 a number of tests were made from samples of the river water taken from different points above the village of Ste Anne's. The ice on the river was about eighteen inches thick, and holes were cut through the ice and the samples taken at various depths by means of Esmarch's[4] apparatus. The water was flowing beneath the ice as the collecting bottle was quickly carried down stream. Other samples were collected in the same manner at various distances from the shore below the village. All samples contained *B. coli* in amounts of less than 1 c.c. of river water. We regarded this infection as coming from Ottawa sewage.

The Water Supply of Montreal.

A word might be said about the probability of infection of the water used by Montreal. Dr. Ruttan, Professor of Chemistry, Faculty of Medicine, McGill University, finds that the alkalinity of the waters of

the St. Lawrence and Ottawa is very constant throughout the year, and as the difference between the alkalinity of two rivers is marked, calculations as to the percentage of Ottawa and St. Lawrence waters as found in the aqueduct water of the city of Montreal at different months may easily be made. Dr. Ruttan thinks his results are very satisfactory and give a very fair estimate of the proportion of Ottawa River and St. Lawrence River waters that find their way into the Montreal water supply during the year 1904-1905.

Percentage of Ottawa River and St. Lawrence River Waters in Montreal Water Supply, 1904-5.

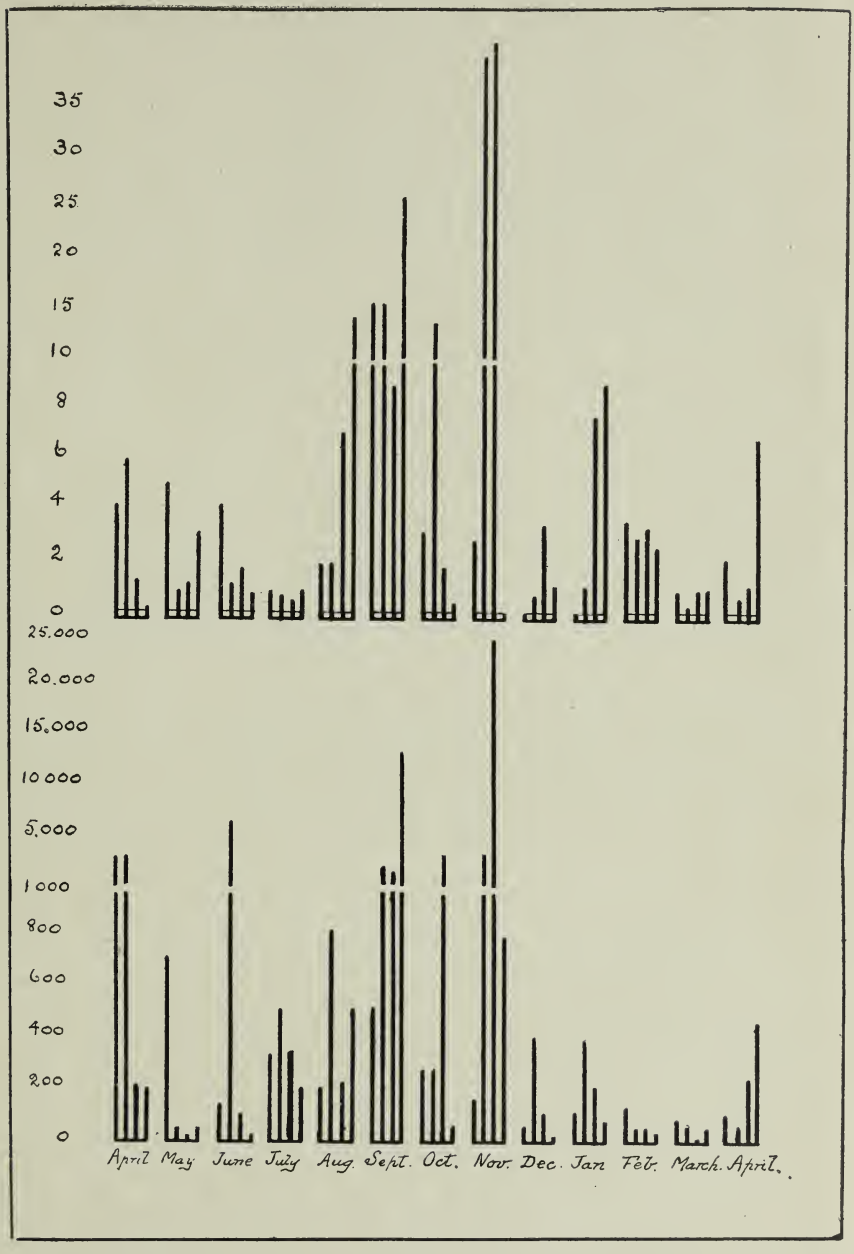
Ottawa River.											
1904					1905						
Nov.	Dec.	Jan.	Feb.	Mar.	April	May	June	July	Aug.	Sept.	Oct.
76.40	56.5	60.7	10.1	4.4	93.7	90.0	50.0	28.5	36.0	34.2	42.2
St. Lawrence River.											
23.60	43.5	39.3	89.9	95.6	6.3	10.0	50.0	71.5	64.0	65.8	57.8

The average for the year is 48 per cent and 52 per cent, respectively, and presuming that the Ottawa water retains its *B. coli* content for some 15 miles beyond Ste. Anne's, the water used in the city of Montreal would contain about the same numbers of *B. coli* as are shown in Table I. According to modern sanitary standards, such water should be inadmissible as a source of supply, unless subjected to preliminary treatment.

Experiments on the Duration of Life of B. coli in Ottawa River water.

Jordan[5] has already pointed out that *B. coli* may be recovered from sewage and polluted river water that has been stored in the laboratory for some weeks. Horrocks[6] recovered *B. coli* which had been placed in flasks of well water and river water kept at room temperature for three months. The organism recovered was more feeble in its indol formation power as compared with the original culture.

As some investigators (Hankin, Russell) have noticed the bactericidal powers of certain river or lake waters it seemed advisable to carry out a number of experiments on the duration of life of *B. coli* in Ottawa River water.



Upper diagram showing number of *B. coli* in Ottawa River water.

Lower diagram showing total number of bacteria growing in beef peptone agar at 37°C.

A small quantity of a young broth culture of *B. coli* obtained from river water was added to each of 4 flasks of river water. Each flask contained two litres of water and two of them were sterilised.

These results showed increase in numbers of *B. coli* in both sterilised and unsterilised water, but the amount of increase was much less in the unsterilised water, possibly due to the competition with other bacteria. A slight trace of peptone would also be present in the flasks from the added broth culture.

	Unsterilised Water		Sterilised Water		
July	Flask 1	Flask 2	Flask 3	Flask 4	
24	7400	15800	291000	17200	
25	280	.....	355000	.....	
26	440	940	330000	22000	
27	240	160000	250000	.....	Flasks kept at 16° to 18°C.
28	640	540000	144000	580.000	
29	400	110000	760000	940000	Figures represent number of
30	145	61000	680000	1030000	*B. coli* per c.c.
31	40	....	490000	695000	

On July 31st we transferred from flasks 3 and 4, 20 to 40 c.c. of water into 6 2-litre flasks of unsterilised river water. Three of these flasks were kept at 16° to 18° C. and three at 25° to 27° C. Each flask was tested daily for the number of *B. coli.*

Number of B. coli per c.c.

	Kept at 16° to 18°C.			Kept at 25° to 27°C.		
	Flask 5	Flask 6	Flask 7	Flask 8	Flask 9	Flask 10
Aug. 1st	8900	19,500	10,400	20,240	9,300	23,400
" 2nd	6900	15,400	6,900	17,000	12,600	14,000
" 3rd	8000	18,700	11,200	10,000	5,500	9,000
" 4th	3700	11,800	6,900	9,200	6,500	9,800
" 5th	4800	6,100	2,000	1,700	2,500	6.500
" 6th	3400	5,000	2,300	4,500	5,250	10,000
" 7th	2200	2,000	2,100	4,500	5,800	11,700

As under natural conditions the numbers of *B. coli* were considerably less; on August 7th, we transferred small quantities of water from flasks 5 to 10 into 6 two-litre flasks of river water; four of these were kept at 10° to 16° C. and two at 22° to 27° C. The number of *B. coli* in each flask was determined daily for a month and after that at week intervals.

NUMBER OF B. COLI PER CC. IN RIVER WATER—KEPT IN FLASKS.

	KEPT AT 10°—16°C.				KEPT AT 22°—27°C.	
	Flask 11	Flask 12	Flask 13	Flask 14	Flask 15	Flask 16
Aug. 10	101	101	54	58	50	84
" 12	24	78	60	54	50	68
" 13	7	65	62	47	37	49
" 14	2	73	53	53	28	40
" 15	2	65	44	54	28	36
" 16	3	63	39	41	28	35
" 17	3	47	41	38	20	25
" 18	2	48	34	50	11	20
" 19	3	60	36	48	10	24
" 20	2	54	29	42	4	22
" 21	1	36	22	39	3	25
" 22	½	68	28	45	3	23
" 23	2	50	25	39	1	15
" 24	1	36	25	44	0	19
" 25	3	33	22	35	½	10
" 26	2	37	20	33	½	12
" 27	2	30	18	22	½	14
" 28	1	23	20	34	1	12
" 29	½	20	22	35	1	7
" 30	1	14	18	31	1	3
" 31	2	14	24	34	½	8
Sept. 1	½	10	18	43	8	1½
" 2	3	10	20	41	3½	3
" 3	2½	8	17	38	1½	2
" 4	1½	8	18	38	2	1
" 5	3	4	12	34	1	2
" 8	1	3	7	38	¼	3
" 13	2½	2½	3½	29	0	1
" 21	3	1½	0	23	¼	1
" 28	¼	¾	¼	15	0	½
Oct. 5	0	¼	0	5	0	½
" 13	0	1	0	6	0	¾
" 18	0	0	..	2	..	..
" 27	..	..	..	1	..	...
Nov. 3	...	..	..	1/5	..	...

The flasks used were of Jena glass and had been carefully washed with potassium bichromate and sulphuric acid, rinsed with distilled water, and sterilised to remove any traces of ammonia.

As it was necessary to remove larger quantities of water to determine the presence of *B. coli* the test was continued, but liquid æsculin

medium was employed instead of æsculin bile-salt-agar plates. When negative results were obtained with 50 c.c. of water from the flasks we assumed that *B. coli* had died out.

On December 23rd, bile salt, peptone and æsculin were added to flask 11 and incubated at 37° C. The contents of the flask were black in 24 hours, and subcultures gave black colonies on æsculin agar plates.

On March 19th, 1909, flasks 12 and 15, and on April 15th, 1909, flasks 14 and 16 were treated in the same manner as flask 11. No change occurred and no black colonies developed on the subcultures.

PRESENCE OF B. COLI IN FLASKS 11 TO 16, TESTED WITH LIQUID AESCULIN MEDIA WITH AND WITHOUT BILE SALT.

A = without bile salt. B = with bile salt. Figures indicate amount of water tested. + = *B. coli*. − = *B. coli* absent.

DATE	Flask 11		Flask 12		Flask 13		Flask 14		Flask 15		Flask 16	
	A	B	A	B	A	B	A	B	A	B	A	B
Aug. 24	..	..	..	..	..	..	..	..	..	1 +	..	..
Sept. 13	..	..	..	..	..	..	..	..	5 +	5 +	..	..
" 21	..	..	..	..	2 +	2 +	..	..	1 +	1 −	..	..
" 28	..	..	..	..	..	..	..	..	5 +	5 −	..	..
Oct. 5	2 +	2 +	..	..	2 +	2 +	..	..	2 +	2 +	..	..
" 13	2 +	4 +	2 −	4 −	2 +	4 −	..	..	2 +	4 −	2 +	4 −
" 18	2 +	10 +	2 +	10 −	2 +	10 +	..	..	2 +	10 +	2 +	10 −
" 27	2 +	10 +	2 −	10 −	2 +	10 +	..	..	2 +	10 −	2	10 −
Nov. 3	2 +	10 +	2 +	20 −	2 +	10 −	..	..	2 +	20 −	2 +	20 +
" 9	5 +	50 −	5 −	20 −	5 +	20 −	1 +	5 +	5 +	50 −	5 +	50 −

These results seem to show that *B. coli* may remain alive in Ottawa River water for a considerable time, for after one hundred and thirty-five (135) days we isolated the colon bacillus from flask 11, and in all 6 flasks it survived for eighty-five days.

Our results also show that prolonged life in water weakens this bacillus, for in many of the later experiments it was unable to grow in the presence of bile salt, a substance which does not restrain the growth of vigorous individuals.

NUMBER OF BACTERIA AND B. COLI IN OTTAWA RIVER WATER—WEEKLY ANALYSIS, APRIL, 1908, TO APRIL, 1909.

	RIVER WATER			FILTERED WATER			REMARKS
	No per c.c. at 20°C.	No. per c.c. at 37°C.	B. coli per 5 c.c.	No. per c.c. at 20°C.	No. per c.c. at 37°C.	B. coli per 5 c.c.	20°C. Beef peptone gel. 37°C. beef peptone agar.
April	18,000	3,000	20	10,000	3,000	10	April, fine weather, snow and ice melting
	12,000	3,000	26	3,000	500	15	
	3,000	200	7	700	200	5	
	3,000	200	1	1,100	200	—	
May.....	5,700	700	25	500	50	0	Rain general over Ottawa valley
	140	40	5	150	4	0	Much rain
	—	25	6	120	40	2	Fine weather
	—	50	13	—	30	—	Fine weather
June.....	360	120	20	2,500	1,100	0	Rain just before the samples were taken
	5,400	6,500	4	200	10	5	Fine weather
	—	70	8	—	1,000	1	" "
	30	20	3	50	30	0	First half of week rain, second half fine
July	—	300	5	500	10	1	Fine weather

Gelatine plates counted at end of 4 or 6 days. Agar plates at end of 2 days' growth.

NUMBER OF BACTERIA AND B. COLI IN OTTAWA RIVER WATER—WEEKLY ANALYSIS, APRIL, 1908, TO APRIL, 1909.—Continued.

	RIVER WATER			FILTERED WATER			REMARKS
	No. per c.c. at 20°C.	No. per c.c. at 37°C.	B. coli per 5 c.c.	No. per c.c. at 20°C.	No. per c.c. at 37°C.	B. coli per 5 c.c.	20°C. Beef peptone gel. 37°C. beef peptone agar.
July	—	500	4	—	10	1	Dry and very warm
	—	300	3	—	150	5	Heavy rain at the end of the week
	—	200	6	—	130	4	Fine
August	—	200	10	—	200	10	Rain followed by fine weather
	—	800	10	—	1,200	18	Heavy rain at the end of the week
	—	200	35	—	150	0	Fine weather
	700	500	75	200	250	5	" "
Sept.....	—	500	80	300	50	25	" "
	300	1,700	80	300	130	25	" "
	600	1,100	45	800	130	40	Light rain at the end of the week
	1,200	13,400	130	800	1,900	35	Fine weather
Oct.....	700	250	15	130	19	0	" "
	850	250	70	140	140	5	Slight rain just before analysis

Gelatine plates counted at end of 4 or 6 days. Agar plates at end of 2 days' growth.

NUMBER OF BACTERIA AND B. COLI IN OTTAWA RIVER WATER—WEEKLY ANALYSIS, APRIL, 1908, TO APRIL, 1909.—Continued.

	RIVER WATER			FILTERED WATER			REMARKS
	No. per c.c. at 20°C.	No. per c.c. at 37°C.f	B. coli per 5 c.c.	No. per c.c. at 20°C.	No. per c.c. at 37°C.	B. coli per 5 c.c.	20°C. Beef peptone gel. 37°C' beef peptone agar.
Oct.....	600	4,500	10	200	—	5	Fine and very warm
	200	70	2	60	10	1	Unsettled weather
Nov.....	250	100	12	60	20	0	Fine weather
	1,500	2,500	200	800	1,000	200	Unsettled weather
	27,000	35,000	2,600	17,000	30,000	15,000	Rain just before analysis
	400	700	0	300	400	0	Heavy precipitation followed by fine weather
Dec.....	250	40	0	90	40	3	Heavy rainfall
	2,000	400	3	1,000	200	3	Snowstorm, river frozen over
	2,000	100	18	300	200	4	River frozen over
	1,600	20	5	200	1,000	0	" " "
Jan.....	500	110	0	350	2,700	0	" " "
	—	400	6	80	200	1	" " "
	400	200	40	300	50	23	" " "

Gelatine plates counted at end of 4 or 6 days. Agar plates at end of 2 days' growth.

NUMBER OF BACTERIA AND B. COLI IN OTTAWA RIVER WATER—WEEKLY ANALYSIS, APRIL, 1908, TO APRIL, 1909.—Continued.

	RIVER WATER			FILTERED WATER			REMARKS
	No. per c.c. at 20°C.	No. per c.c. at 37°C.	B. coli per 5 c.c.	No. per c.c. at 20°C.	No. per c.c. at 37°C.	B. coli per 5 c.c.	20°C. Beef peptone gel. 37°C beef peptone agar.
Jan	600	80	44	—	50	3	River frozen over
Feb.....	500	140	18	300	70	12	" " "
	70	50	16	30	30	14	" " "
	120	50	17	30	40	7	" " "
	100	40	13	80	50	4	" " "
Mar.....	80	60	5	50	20	4	" " "
	70	30	3	70	30	1	" " "
	700	10	6	500	30	2	" " "
	500	30	6	300	80	1	" " "
April	800	70	9	500	30	5	" " "
	850	20	4	200	20	1	River ice breaking up
	1,400	220	7	800	250	4	Ice disappeared from river
	liq.	400	33	liq.	180	3	Unsettled weather

Gelatine plates counted at end of 4 or 6 days. Agar plates at end of 2 days' growth.

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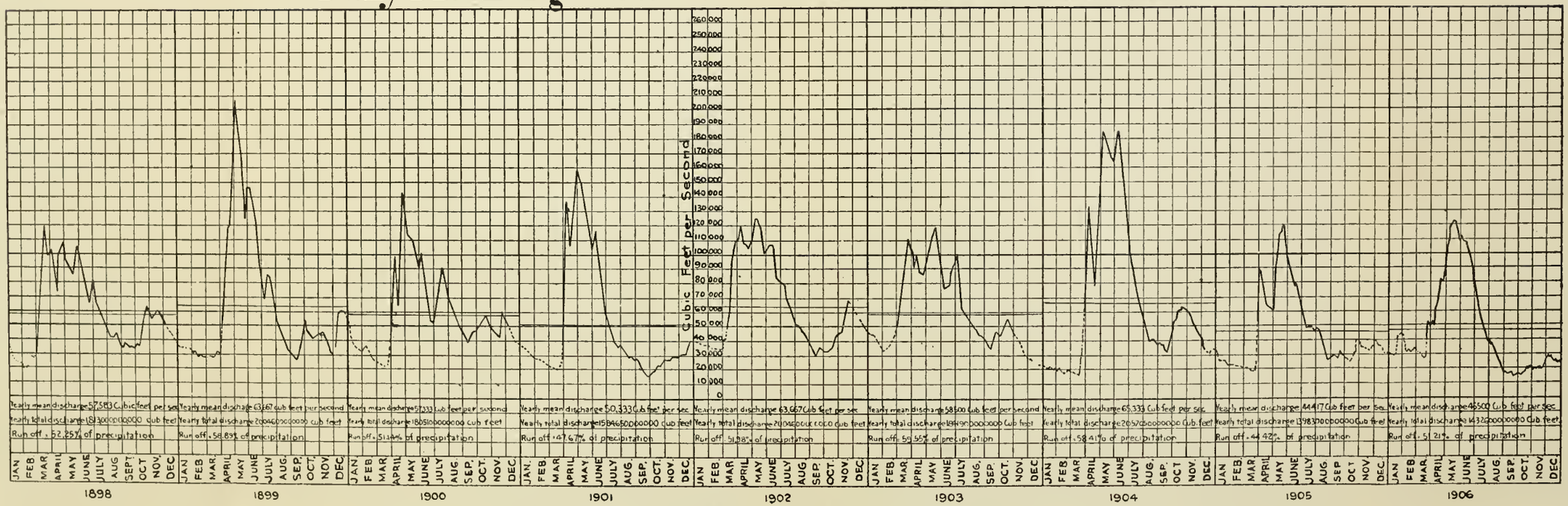
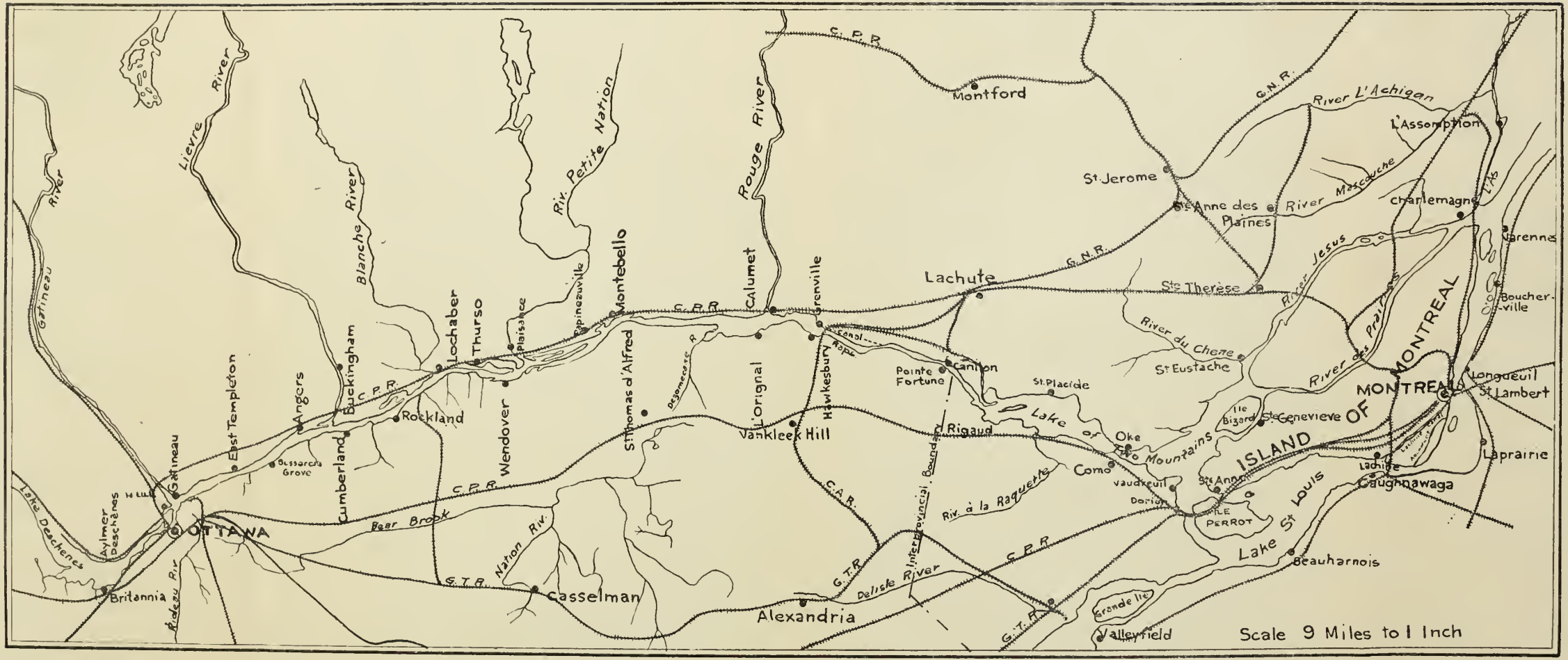
Daily Discharge of the Ottawa River at Besserers Grove



The straight lines indicate yearly averages


Gatineau River
Lievre River
Blanche River
Riv. Petite Nation
Rouge River
C.P.R.
Montford
G.N.R.
River L'Achigan
L'Assomption
St. Jerome
Ste Anne des Plaines
River Mascouche
Charlemagne
L'Ass
Terrenne
Boucherville
Lachute
Ste Therese
River Jesus
River des Prairies
MONTREAL
Longueuil
St Lambert
Laprairie
Caughnawaga
Lake St Louis
Beauharnois
Valleyfield
Grande Ile
ISLAND OF MONTREAL
Ile Bizard
Ste Genevieve
Ste Anne
Ile Perrot
Vaudreuil
Dorion
Como
Oka
Two Mountains
Lake of
St Placide
Pointe Fortune
Carillon
River du Chene
St Eustache
Grenville
Calumet
Montebello
Papineauville
Plaisance
Thurso
Lochaber
Buckingham
Angers
East Templeton
Gatineau
Cumberland
Rockland
Wendover
St Thomas d'Alfred
L'Orignal
Vankleek Hill
Hawkesbury
Rigaud
Rivière à la Raquette
Interprovincial Bound.
Delisle River
Nation Riv.
Bear Brook
Rideau Riv.
Lake Deschenes
Aylmer
Deschênes
Hull
OTTAWA
Britannia
Casselman
Alexandria
Bessarcis Grove
C.A.R.
G.T.R.
Scale 9 Miles to 1 Inch

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